

May 21, 2002

TO: SAO/Bob Rasche  
FROM: 551/Timo Saha

**SUBJECT: CSX/STX telescope design data for 200 mm and 300 mm long mirrors**

This memo describes the updated telescope designs for the Constellation-X/SXT project. The most important change is to limit the mirror axial length to a range from 200 mm to 300 mm. The design data are listed in Tables 1 and 2 and the on-axis effective area in the SXT energy range is plotted in Figure 1 and listed in Tables 3 and 4.

My requirements/assumptions for the designs are:

**Axial distance from the primary-secondary intersection plane to telescope focus  $L_{int} = 10$  m**

**Primary and secondary mirror axial length ( $l_p$  and  $l_s$ ) = 200 mm or 300 mm**

**Maximum radial height at the intersection plane ( $h_{int}$ ) = 800 mm**

**Minimum radial height at the intersection plane ( $h_{int}$ ) ~ 150 mm**

**Axial distance from the back of the primary to the intersection plane  $c_p = 25.1$  mm**

**Axial distance from the intersection plane to the front of the secondary  $c_s = 24.9$  mm**

**Gap between the primary and secondary = 50 mm ( $c_p+c_s$ )**

**Mirror shell thickness = 0.44 mm**

**Telescope field of view (FOV)= 2.5 arcminutes**

**Mirror shell radial tolerance=0.2 mm**

The mirror thickness is assumed to be 0.44 mm. This thickness includes the thickness of the glass sheet and the epoxy layer.

The cap length between the primary and secondary is identical with the CSX/OAP design. I have moved the primary-secondary intersection plane 0.1mm towards the secondary mirror. This prevents any on-axis rays from missing the front edges of the secondary mirrors.

The mirror shells are placed so that all the rays within the FOV pass the front and back edges of adjacent inner mirrors. The radial clearance for the extreme ray is 0.2 mm. This tolerance is added to prevent misaligned mirrors from obstructing the FOV.

Under these assumptions 230 mirror shells that are 200 mm long can be fit between the maximum and minimum radial heights. The radial and axial dimensions of the shells are given in Table 1. In case of 300-mm long mirrors, 167 shells can be placed between the telescope radial range. The radial and axial dimensions of this design are given in Table 2.

The weight estimate is based on the mass of glass and the epoxy layer. I assumed the epoxy layer would have the same density as the glass. The 200-mm long mirrors would weigh 262 kg and 300-mm long mirrors would weigh 281 kg.

The basic parameters of Wolter type 1 telescope are radius of curvature ( $R_p$ ) of the parabolic primary mirrors and the radius of curvature ( $R_s$ ) and the eccentricity ( $\varepsilon$ ) of the hyperbolic secondary mirrors. These parameters can be calculated from the design data listed in the Tables. Assuming that the grazing angle on the primary mirror and on the secondary mirror is the same at the intersection plane, then, the parameters can be calculated from  $L_{int}$  and  $h_{int}$  values using equations:

$$\alpha = a \tan(h_{int} / L_{int})$$

$$R_p = -h_{int} \tan(\alpha / 4)$$

$$\varepsilon = \frac{1}{2 \cos(\frac{\alpha}{2}) - 1}$$

$$R_s = \varepsilon R_p$$

In the OSAC ray trace program the surfaces are described with a different set of parameters ( $\rho_0$ , K, P). The basic equation of the surface in the body-centered coordinate system ( $\rho-z$ ) of the OSAC program is:

$$\rho^2 = \rho_0^2 + 2Kz - Pz^2$$

The OSAC parameters can be calculated from the following equations:

$$\rho_{0p} = \sqrt{2R_p \left( \frac{R_p}{2} + \frac{2R_s \epsilon}{\epsilon^2 - 1} - L_{int} - \frac{L_p}{2} - c_p \right)}$$

$$K_p = R_1$$

$$P_p = 0.$$

$$\rho_{0s} = \sqrt{(\epsilon^2 - 1) \left( L_{int} - \frac{R_s \epsilon}{\epsilon^2 - 1} - \frac{l_s}{2} - c_s \right)^2 - \frac{R_s^2}{\epsilon^2 - 1}}$$

$$P_s = 1 - \epsilon^2$$

$$K_s = \frac{\rho_{0s}^2 - h_{int}^2 - P_s \left( \frac{l_s}{2} + c_s \right)}{l_s + 2c_s},$$

where sub index p refers to the parabolic primary mirror and s to the hyperbolic secondary mirror.

Figure 1 plots the on-axis effective area of the designs in the SXT energy range. The effective area values are also tabulated in Tables 3 and 4. I have used the optical constants of gold (published by LBL). I assumed gold density of 18.85 gm/cm<sup>3</sup>. I also assumed that 25% of the area would be obscured by structures (mirror mounts, pre-collimator and post-collimator) in the mirror aperture. The obscuration also includes the circumferential caps between the mirror segments. The longer axial length design provides higher effective area across the energy range.

Timo Saha

**Table 1. Basic design information, axial distances, and radial heights for the CSX/SXT telescope design assuming mirror axial length of 200 mm.**

Axial length from intersection plane to focal plane=1.0e+004 mm  
 Axial length from the front of the primary to foacal plane=1.02251e+004 mm  
 Primay cap= 2.51e+001 mm  
 Secondary cap=2.49e+001 mm  
 Primary-secondary gap=5.0d+001 mm  
 Mirror thickness= 0.44 mm  
 Half field of view 1.25 arcminutes  
 Radial tolerance= 0.2 mm  
 Mirror weight ~ 262 kg

zp_front(mm)	zp_back (mm)	z_intersection(mm)	zs_front (mm)	zs_back (mm)
0.0e+000	2.00e+002	2.251e+002	2.50e+002	4.5e+002
shell	hp_max (mm)	hp_min (mm)	h_intersection(mm)	hs_max (mm)
1	8.0448048216e+002	8.0050084278e+002	7.99999999988e+002	7.9850723577e+002
2	7.9965144371e+002	7.9569559944e+002	7.9519775115e+002	7.9371393132e+002
3	7.9484714754e+002	7.9091497814e+002	7.9042010933e+002	7.8894518823e+002
4	7.9006746452e+002	7.8615885033e+002	7.8566694595e+002	7.8420087827e+002
5	7.8531226622e+002	7.8142708820e+002	7.8093813326e+002	7.7948087394e+002
6	7.8058142493e+002	7.7671956461e+002	7.7623354420e+002	7.7478504840e+002
7	7.7587481362e+002	7.7203615314e+002	7.7155305243e+002	7.7011327554e+002
8	7.7119230598e+002	7.6737672807e+002	7.6689653230e+002	7.6546542994e+002
9	7.6653377639e+002	7.6274116435e+002	7.6226385884e+002	7.6084138685e+002
10	7.6189909991e+002	7.5812933764e+002	7.5765490778e+002	7.5624102222e+002
11	7.5728815229e+002	7.5354112426e+002	7.5306955551e+002	7.5166421269e+002
12	7.5270080996e+002	7.4897640124e+002	7.4850767913e+002	7.4711083556e+002
13	7.4813695004e+002	7.4443504625e+002	7.4396915639e+002	7.4258076881e+002
14	7.4359645030e+002	7.3991693764e+002	7.3945386571e+002	7.3807389109e+002
15	7.3907918919e+002	7.3542195444e+002	7.3496168620e+002	7.3359008171e+002
16	7.3458504584e+002	7.3094997633e+002	7.3049249759e+002	7.2912922064e+002
17	7.3011390001e+002	7.2650088365e+002	7.2604618030e+002	7.2469118850e+002
18	7.2566563214e+002	7.2207455739e+002	7.2162261540e+002	7.2027586659e+002
19	7.2124012330e+002	7.1767087919e+002	7.1722168459e+002	7.1588313683e+002
20	7.1683725523e+002	7.1328973134e+002	7.1284327024e+002	7.1151288178e+002
21	7.1245691030e+002	7.0893099676e+002	7.0848725533e+002	7.0716498465e+002
22	7.0809897154e+002	7.0459455903e+002	7.0415352351e+002	7.0283932931e+002
23	7.0376332257e+002	7.0028030233e+002	6.9984195904e+002	6.9853580021e+002
24	6.9944984771e+002	6.9598811151e+002	6.9555244682e+002	6.9425428248e+002
25	6.9515843184e+002	6.9171787200e+002	6.9128487237e+002	6.8999466184e+002
26	6.9088896051e+002	6.8746946990e+002	6.8703912184e+002	6.8575682464e+002
27	6.8664131987e+002	6.8324279188e+002	6.8281508198e+002	6.8154065785e+002
28	6.8241539671e+002	6.7903772527e+002	6.7861264017e+002	6.7734604905e+002
29	6.7821107839e+002	6.7485415797e+002	6.7443168440e+002	6.7317288643e+002
30	6.7402825293e+002	6.7069197851e+002	6.7027210325e+002	6.6902105879e+002
31	6.6986680892e+002	6.6655107603e+002	6.6613378594e+002	6.6489045553e+002
32	6.6572663556e+002	6.6243134025e+002	6.6201662223e+002	6.6078096664e+002
33	6.6160762266e+002	6.5833266149e+002	6.5792050254e+002	6.5669248270e+002
34	6.5750966062e+002	6.5425493067e+002	6.5384531783e+002	6.5262489491e+002
35	6.5343264041e+002	6.5019803930e+002	6.4979095969e+002	6.4857809502e+002
36	6.4937645363e+002	6.4616187946e+002	6.4575732025e+002	6.4455197540e+002
37	6.4534099242e+002	6.4214634383e+002	6.4174429226e+002	6.4054642897e+002
38	6.4132614953e+002	6.3815132565e+002	6.3775176904e+002	6.3656134923e+002
39	6.3733181828e+002	6.3417671875e+002	6.3377964446e+002	6.3259663029e+002



96 4.4035477467e+002 4.3817339177e+002 4.3789886077e+002 4.3708122818e+002 4.3050762714e+002  
97 4.3738567456e+002 4.3521898240e+002 4.3494630025e+002 4.3413417756e+002 4.2760487492e+002  
98 4.3443170127e+002 4.3227962535e+002 4.3200878268e+002 4.3120214186e+002 4.2471691243e+002  
99 4.3149277723e+002 4.2935524344e+002 4.2908623091e+002 4.2828504411e+002 4.2184366384e+002  
100 4.285682531e+002 4.2644575989e+002 4.2617856823e+002 4.2538280771e+002 4.1898505367e+002  
101 4.2565976874e+002 4.2355109833e+002 4.2328571829e+002 4.2249535648e+002 4.1614100689e+002  
102 4.2276553119e+002 4.2067118277e+002 4.2040760518e+002 4.1962261461e+002 4.1331144884e+002  
103 4.1988603669e+002 4.1780593763e+002 4.1754415334e+002 4.1676450673e+002 4.1049630523e+002  
104 4.1702120971e+002 4.1495528773e+002 4.1469528766e+002 4.1392095782e+002 4.0769550219e+002  
105 4.1417097508e+002 4.1211915829e+002 4.1186093337e+002 4.1109189329e+002 4.0490896623e+002  
106 4.1133525803e+002 4.0929747489e+002 4.0904101612e+002 4.0827723891e+002 4.0213662423e+002  
107 4.0851398421e+002 4.0649016353e+002 4.0623546196e+002 4.0547692086e+002 3.9937840345e+002  
108 4.0570707961e+002 4.0369715057e+002 4.0344419729e+002 4.0269086568e+002 3.9663423156e+002  
109 4.0291447064e+002 4.0091836278e+002 4.0066714891e+002 3.9991900032e+002 3.9390403658e+002  
110 4.0013608409e+002 3.9815372731e+002 3.9790424403e+002 3.9716125210e+002 3.9118774692e+002  
111 3.9737184711e+002 3.9540317165e+002 3.9515541019e+002 3.9441754872e+002 3.8848529134e+002  
112 3.9462168727e+002 3.9266662373e+002 3.9242057535e+002 3.9168781825e+002 3.8579659900e+002  
113 3.9188553247e+002 3.8994401181e+002 3.8969966782e+002 3.8897198915e+002 3.8312159942e+002  
114 3.8916331103e+002 3.8723526454e+002 3.8699261630e+002 3.8626999023e+002 3.8046022249e+002  
115 3.8645495160e+002 3.8454031094e+002 3.8429934984e+002 3.8358175070e+002 3.7781239844e+002  
116 3.8376038325e+002 3.8185908040e+002 3.8161979788e+002 3.8090720012e+002 3.7517805791e+002  
117 3.8107953537e+002 3.7919150267e+002 3.7895389023e+002 3.7824626842e+002 3.7255713187e+002  
118 3.7841233776e+002 3.7653750789e+002 3.7630155704e+002 3.7559888589e+002 3.6994955165e+002  
119 3.7575872056e+002 3.7389702654e+002 3.7366272886e+002 3.7296498320e+002 3.6735524894e+002  
120 3.7311861428e+002 3.7126998946e+002 3.7103733656e+002 3.7034449136e+002 3.6477415580e+002  
121 3.7049194979e+002 3.6865632787e+002 3.6842531141e+002 3.6773734176e+002 3.6220620462e+002  
122 3.6787865833e+002 3.6605597333e+002 3.6582658500e+002 3.6514346612e+002 3.5965132817e+002  
123 3.6527867147e+002 3.6346885777e+002 3.6324108931e+002 3.6256279654e+002 3.5710945954e+002  
124 3.6269192117e+002 3.6089491346e+002 3.6066875665e+002 3.5999526546e+002 3.5458053219e+002  
125 3.6011833973e+002 3.5833407302e+002 3.5810951969e+002 3.5744080567e+002 3.5206447991e+002  
126 3.5755785978e+002 3.5578626944e+002 3.5556331145e+002 3.5489935033e+002 3.4956123686e+002  
127 3.5501041434e+002 3.5325143605e+002 3.5303006531e+002 3.5237083291e+002 3.4707073750e+002  
128 3.5247593675e+002 3.5072950651e+002 3.5050971496e+002 3.4985518726e+002 3.4459291666e+002  
129 3.4995436070e+002 3.4822041484e+002 3.4800219447e+002 3.4735234755e+002 3.4212770952e+002  
130 3.4744562023e+002 3.4572409540e+002 3.4550743824e+002 3.4486224831e+002 3.3967505156e+002  
131 3.4494964972e+002 3.4324048289e+002 3.4302538100e+002 3.4238482440e+002 3.3723487862e+002  
132 3.4246638388e+002 3.4076951235e+002 3.4055595785e+002 3.3992001102e+002 3.3480712687e+002  
133 3.3999575779e+002 3.3831111916e+002 3.3809910418e+002 3.3746774370e+002 3.3239173281e+002  
134 3.3753770682e+002 3.3586523902e+002 3.3565475576e+002 3.3502795831e+002 3.2998863326e+002  
135 3.3509216672e+002 3.3343180798e+002 3.3322284867e+002 3.3260059105e+002 3.2759776538e+002  
136 3.3265907354e+002 3.3101076241e+002 3.3080331931e+002 3.3018557846e+002 3.2521906665e+002  
137 3.3023836368e+002 3.2860203903e+002 3.2839610445e+002 3.2778285739e+002 3.2285247488e+002  
138 3.2782997386e+002 3.2620557485e+002 3.2600114113e+002 3.2539236505e+002 3.2049792820e+002  
139 3.2543384113e+002 3.2382130725e+002 3.2361836678e+002 3.2301403893e+002 3.1815536504e+002  
140 3.2304990288e+002 3.2144917390e+002 3.2124771909e+002 3.2064781688e+002 3.1582472418e+002  
141 3.2067809679e+002 3.1908911281e+002 3.1888913614e+002 3.1829363706e+002 3.1350594471e+002  
142 3.1831836090e+002 3.1674106231e+002 3.1654255626e+002 3.1595143795e+002 3.1119896601e+002  
143 3.1597063356e+002 3.1440496105e+002 3.1420791816e+002 3.1362115834e+002 3.0890372781e+002  
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147 3.0669858758e+002 3.0517883232e+002 3.0498756819e+002 3.0441802195e+002 2.9983898510e+002  
148 3.0440998920e+002 3.0290156796e+002 3.0271173024e+002 3.0214643285e+002 2.9760155593e+002  
149 3.0213303607e+002 3.0063589133e+002 3.0044747277e+002 2.9988640264e+002 2.9537551202e+002  
150 2.9986766872e+002 2.9838174324e+002 2.9819473665e+002 2.9763787229e+002 2.9316079525e+002  
151 2.9761382801e+002 2.9613906484e+002 2.9595346304e+002 2.9540078308e+002 2.9095734776e+002



208	1.8641598193e+002	1.8549208421e+002	1.8537580985e+002	1.8502960188e+002	1.8224615979e+002
209	1.8473918427e+002	1.8382359520e+002	1.8370836649e+002	1.8336527234e+002	1.8060686465e+002
210	1.8307091245e+002	1.8216358982e+002	1.8204940146e+002	1.8170940530e+002	1.7897590479e+002
211	1.8141112304e+002	1.8051202488e+002	1.8039887158e+002	1.8006195766e+002	1.7735323776e+002
212	1.7975977286e+002	1.7886885739e+002	1.7875673390e+002	1.7842288655e+002	1.7573882132e+002
213	1.7811681893e+002	1.7723404458e+002	1.7712294567e+002	1.7679214932e+002	1.7413261346e+002
214	1.7648221850e+002	1.7560754393e+002	1.7549746439e+002	1.7516970353e+002	1.7253457239e+002
215	1.7485592903e+002	1.7398931310e+002	1.7388024775e+002	1.7355550695e+002	1.7094465651e+002
216	1.7323790820e+002	1.7237930998e+002	1.7227125368e+002	1.7194951760e+002	1.6936282446e+002
217	1.7162811393e+002	1.7077749269e+002	1.7067044031e+002	1.7035169367e+002	1.6778903507e+002
218	1.7002650432e+002	1.6918381954e+002	1.6907776598e+002	1.6876199360e+002	1.6622324739e+002
219	1.6843303770e+002	1.6759824908e+002	1.6749318927e+002	1.6718037602e+002	1.6466542068e+002
220	1.6684767262e+002	1.6602074005e+002	1.6591666893e+002	1.6560679979e+002	1.6311551442e+002
221	1.6527036783e+002	1.6445125140e+002	1.6434816397e+002	1.6404122396e+002	1.6157348827e+002
222	1.6370108231e+002	1.6288974232e+002	1.6278763356e+002	1.6248360781e+002	1.6003930212e+002
223	1.6213977521e+002	1.6133617217e+002	1.6123503712e+002	1.6093391081e+002	1.5851291605e+002
224	1.6058640595e+002	1.5979050055e+002	1.5969033426e+002	1.5939209265e+002	1.5699429036e+002
225	1.5904093409e+002	1.5825268723e+002	1.5815348479e+002	1.5785811323e+002	1.5548338554e+002
226	1.5750331945e+002	1.5672269224e+002	1.5662444874e+002	1.5633193264e+002	1.5398016229e+002
227	1.5597352203e+002	1.5520047575e+002	1.5510318633e+002	1.5481351119e+002	1.5248458151e+002
228	1.5445150204e+002	1.5368599819e+002	1.5358965800e+002	1.5330280937e+002	1.5099660429e+002
229	1.5293721990e+002	1.5217922016e+002	1.5208382438e+002	1.5179978789e+002	1.4951619192e+002
230	1.5143063621e+002	1.5068010247e+002	1.5058564630e+002	1.5030440767e+002	1.4804330592e+002

**Table 2. Basic design information, axial distances, and radial heights for the CSX/SXT telescope design assuming mirror axial length of 300 mm.**

Axial length from intersection plane to focal plane = 1.0e+004 mm  
 Axial length from the front of the primary to foacal plane = 1.03251e+004 mm  
 Primay cap = 2.51e+001 mm  
 Secondary cap = 2.49e+001 mm  
 Primary-secondary cap = 5.0d+001 mm  
 Mirror thickness = 0.44 mm  
 Half field of view = 1.25 arcminutes  
 Radial tolerance = 0.2 mm  
 Number of shells = 167  
 Mirror weight ~ 281 kg

zp_front(mm)	zp_back (mm)	z_intersection(mm)	zs_front (mm)	zs_back (mm)	
0.0e+000	3.00e+002	3.251e+002	3.50e+002	6.5e+002	
shell	hp_max (mm)	hp_min (mm)	h_intersection(mm)	hs_max (mm)	hs_min (mm)
1	8.0646293737e+002	8.0050084260e+002	7.9999999970e+002	7.9850723560e+002	7.8049712328e+002
2	7.9948450944e+002	7.9357380532e+002	7.9307727939e+002	7.9159740907e+002	7.7374285945e+002
3	7.9256005132e+002	7.8670034552e+002	7.8620810363e+002	7.8474102796e+002	7.6704084517e+002
4	7.8568913828e+002	7.7988004148e+002	7.7939205090e+002	7.7793767153e+002	7.6039066895e+002
5	7.7887134914e+002	7.7311247492e+002	7.7262870320e+002	7.7118692254e+002	7.5379192271e+002
6	7.7210626616e+002	7.6639723105e+002	7.6591764598e+002	7.644836719e+002	7.4724420174e+002
7	7.6539347508e+002	7.5973389850e+002	7.5925846811e+002	7.5784159511e+002	7.4074710468e+002
8	7.5873256505e+002	7.5312206930e+002	7.5265076187e+002	7.5124619929e+002	7.3430023352e+002
9	7.5212312860e+002	7.4656133884e+002	7.4609412288e+002	7.4470177612e+002	7.2790319349e+002
10	7.4556476162e+002	7.4005130585e+002	7.3958815012e+002	7.3820792529e+002	7.2155559311e+002
11	7.3905706333e+002	7.3359157236e+002	7.3313244584e+002	7.3176424978e+002	7.1525704411e+002
12	7.3259963621e+002	7.2718174367e+002	7.2672661558e+002	7.2537035586e+002	7.0900716142e+002
13	7.2619208605e+002	7.2082142832e+002	7.2037026812e+002	7.1902585301e+002	7.0280556313e+002
14	7.1983402184e+002	7.1451023805e+002	7.1406301543e+002	7.1273035392e+002	6.9665187049e+002
15	7.1352505578e+002	7.0824778781e+002	7.0780447269e+002	7.0648347445e+002	6.9054570782e+002
16	7.0726480324e+002	7.0203369569e+002	7.0159425821e+002	7.0028483363e+002	6.8448670255e+002
17	7.0105288273e+002	6.9586758288e+002	6.9543199342e+002	6.9413405357e+002	6.7847448515e+002
18	6.9488891590e+002	6.8974907371e+002	6.8931730285e+002	6.8803075950e+002	6.7250868911e+002
19	6.8877252745e+002	6.8367779553e+002	6.8324981411e+002	6.8197457968e+002	6.6658895091e+002
20	6.8270334517e+002	6.7765337877e+002	6.7722915781e+002	6.7596514543e+002	6.6071491002e+002
21	6.7668099985e+002	6.7167545683e+002	6.7125496761e+002	6.7000209106e+002	6.5488620883e+002
22	6.7070512532e+002	6.6574366614e+002	6.6532688013e+002	6.6408505386e+002	6.4910249265e+002
23	6.6477535835e+002	6.5985764605e+002	6.5944453494e+002	6.5821367406e+002	6.4336340967e+002
24	6.5889133868e+002	6.5401703886e+002	6.5360757456e+002	6.5238759484e+002	6.3766861095e+002
25	6.5305270898e+002	6.4822148975e+002	6.4781564439e+002	6.4660646224e+002	6.3201775040e+002
26	6.4725911480e+002	6.4247064682e+002	6.4206839273e+002	6.4086992520e+002	6.2641048471e+002
27	6.4151020455e+002	6.3676416098e+002	6.3636547070e+002	6.3517763549e+002	6.2084647337e+002
28	6.3580562953e+002	6.3110168598e+002	6.3070653228e+002	6.2952924772e+002	6.1532537864e+002
29	6.3014504381e+002	6.2548287839e+002	6.2509123422e+002	6.2392441928e+002	6.0984686549e+002
30	6.2452810428e+002	6.1990739754e+002	6.1951923605e+002	6.1836281031e+002	6.0441060162e+002
31	6.1895447059e+002	6.1437490550e+002	6.1399020008e+002	6.1284408374e+002	5.9901625742e+002
32	6.1342380516e+002	6.0888506709e+002	6.0850379130e+002	6.0736790518e+002	5.9366350592e+002
33	6.0793577309e+002	6.0343754981e+002	6.0305967743e+002	6.0193394297e+002	5.8835202282e+002
34	6.0249004222e+002	5.9803202387e+002	5.9765752887e+002	5.9654186809e+002	5.8308148640e+002
35	5.9708628302e+002	5.9266816211e+002	5.9229701865e+002	5.9119135420e+002	5.7785157756e+002
36	5.9172416865e+002	5.8734564000e+002	5.8697782246e+002	5.8588207756e+002	5.7266197977e+002
37	5.8640337487e+002	5.8206413565e+002	5.8169961857e+002	5.8061371705e+002	5.6751237902e+002
38	5.8112358005e+002	5.7682332971e+002	5.7646208787e+002	5.7538595413e+002	5.6240246386e+002





151	1.8461593778e+002	1.8324854177e+002	1.8313367346e+002	1.8279165250e+002	1.7866519005e+002
152	1.8242498791e+002	1.8107381632e+002	1.8096031094e+002	1.8062234857e+002	1.7654485275e+002
153	1.8025085466e+002	1.7891578309e+002	1.7880363019e+002	1.7846969527e+002	1.7444079039e+002
154	1.7809340881e+002	1.7677431378e+002	1.7666350300e+002	1.7633356463e+002	1.7235287790e+002
155	1.7595252211e+002	1.7464928111e+002	1.7453980215e+002	1.7421382966e+002	1.7028099114e+002
156	1.7382806729e+002	1.7254055875e+002	1.7243240139e+002	1.7211036438e+002	1.6822500696e+002
157	1.7171991810e+002	1.7044802137e+002	1.7034117548e+002	1.7002304373e+002	1.6618480315e+002
158	1.6962794923e+002	1.6837154459e+002	1.6826600012e+002	1.6795174368e+002	1.6416025844e+002
159	1.6755203636e+002	1.6631100501e+002	1.6620675197e+002	1.6589634110e+002	1.6215125250e+002
160	1.6549205611e+002	1.6426628015e+002	1.6416330864e+002	1.6385671385e+002	1.6015766592e+002
161	1.6344788606e+002	1.6223724851e+002	1.6213554870e+002	1.6183274070e+002	1.5817938023e+002
162	1.6141940475e+002	1.6022378950e+002	1.6012335165e+002	1.5982430139e+002	1.5621627785e+002
163	1.5940649162e+002	1.5822578348e+002	1.5812659790e+002	1.5783127656e+002	1.5426824212e+002
164	1.5740902709e+002	1.5624311173e+002	1.5614516882e+002	1.5585354778e+002	1.5233515728e+002
165	1.5542689245e+002	1.5427565643e+002	1.5417894666e+002	1.5389099753e+002	1.5041690847e+002
166	1.5345996995e+002	1.5232330069e+002	1.5222781460e+002	1.5194350921e+002	1.4851338170e+002
167	1.5150814271e+002	1.5038592849e+002	1.5029165670e+002	1.5001096710e+002	1.4662446387e+002

**Table 3. On-axis effective area of the CSX/SXT telescope design assuming 200 mm long mirrors.**Coating Gold (LBL optical constants), density 18.85 gm/cm<sup>3</sup>

Aperture obscuration=0.75

Energy (KeV) Effective area (cm<sup>2</sup>)

0.248	8087.9
0.252	8064.0
0.256	8043.6
0.260	8021.5
0.264	8000.4
0.268	7981.9
0.273	7968.8
0.277	7955.1
0.281	7956.6
0.286	7943.4
0.291	7929.3
0.295	7915.0
0.300	7901.1
0.305	7888.4
0.310	7878.7
0.315	7871.2
0.320	7861.9
0.325	7851.4
0.330	7840.9
0.336	7831.2
0.341	7822.7
0.347	7816.7
0.352	7817.5
0.358	7819.1
0.364	7816.5
0.370	7811.4
0.376	7805.4
0.382	7798.9
0.388	7792.7
0.394	7787.3
0.401	7785.0
0.407	7786.8
0.414	7785.8
0.420	7781.5
0.427	7775.9
0.434	7769.7
0.441	7763.1
0.448	7757.4
0.455	7753.6
0.463	7748.3
0.470	7741.3
0.478	7733.2
0.486	7724.5
0.493	7715.3
0.501	7705.7
0.510	7696.2
0.518	7686.8
0.526	7676.8
0.535	7666.6
0.543	7656.1
0.552	7645.6

0.561	7635.2
0.570	7625.9
0.579	7616.8
0.589	7607.2
0.598	7597.7
0.608	7588.3
0.618	7579.4
0.628	7571.2
0.638	7564.3
0.648	7560.5
0.659	7565.2
0.669	7569.6
0.680	7569.5
0.691	7567.9
0.702	7565.1
0.714	7561.4
0.725	7556.7
0.737	7551.0
0.749	7545.5
0.761	7540.1
0.773	7535.1
0.786	7530.4
0.799	7529.0
0.811	7531.5
0.825	7531.8
0.838	7531.7
0.852	7531.8
0.865	7532.3
0.879	7539.1
0.893	7553.4
0.908	7563.0
0.923	7571.1
0.938	7578.5
0.953	7586.4
0.968	7597.8
0.984	7609.3
1.000	7619.4
1.016	7629.2
1.032	7643.0
1.049	7667.4
1.066	7691.5
1.083	7711.8
1.101	7729.6
1.119	7745.6
1.137	7759.8
1.155	7772.6
1.174	7784.0
1.193	7793.9
1.212	7801.9
1.232	7804.8
1.251	7801.4
1.272	7799.4
1.292	7797.9
1.313	7798.1
1.334	7805.3
1.356	7811.9

1.378	7816.5
1.400	7819.8
1.423	7820.0
1.446	7811.9
1.469	7805.2
1.493	7804.5
1.517	7832.5
1.542	7852.9
1.567	7859.1
1.592	7847.0
1.618	7835.9
1.644	7827.0
1.671	7827.3
1.698	7814.0
1.725	7790.5
1.753	7774.4
1.781	7736.1
1.810	7691.9
1.839	7670.1
1.869	7628.9
1.899	7574.7
1.930	7539.3
1.961	7502.1
1.993	7437.7
2.025	7359.5
2.058	7274.0
2.091	7167.9
2.125	7026.0
2.159	6814.4
2.194	6470.2
2.230	4785.5
2.266	3067.1
2.303	2899.9
2.340	2524.2
2.378	2815.6
2.416	3043.1
2.455	3171.2
2.495	3256.5
2.535	3335.0
2.576	3398.7
2.618	3404.5
2.660	3384.9
2.703	3303.4
2.747	3065.3
2.791	3116.6
2.837	3237.8
2.882	3286.4
2.929	3338.2
2.976	3382.3
3.025	3404.8
3.074	3415.9
3.123	3402.0
3.174	3325.8
3.225	3308.4
3.277	3350.5
3.330	3365.7

3.384	3359.5
3.439	3314.6
3.494	3311.6
3.551	3356.5
3.608	3355.2
3.667	3347.9
3.726	3335.2
3.786	3317.9
3.848	3301.7
3.910	3279.7
3.973	3252.4
4.037	3222.1
4.103	3190.7
4.169	3156.5
4.236	3125.5
4.305	3053.3
4.375	3013.3
4.445	2962.6
4.517	2914.9
4.590	2863.7
4.665	2812.3
4.740	2759.1
4.817	2704.3
4.895	2647.5
4.974	2590.7
5.054	2530.4
5.136	2474.6
5.219	2420.2
5.303	2354.0
5.389	2313.2
5.476	2259.4
5.565	2206.8
5.655	2153.6
5.746	2100.0
5.839	2046.2
5.934	2001.6
6.030	1946.2
6.127	1898.6
6.226	1850.0
6.327	1801.5
6.429	1753.6
6.533	1706.1
6.639	1659.2
6.747	1612.8
6.856	1567.0
6.967	1521.9
7.079	1477.3
7.194	1433.4
7.310	1390.1
7.428	1347.5
7.548	1305.6
7.671	1264.4
7.795	1223.9
7.921	1184.0
8.049	1144.9
8.179	1106.4

8.311	1068.7
8.446	1031.7
8.582	995.4
8.721	959.7
8.862	924.8
9.005	890.6
9.151	857.0
9.299	824.1
9.450	791.9
9.602	760.3
9.758	729.3
9.916	699.0
10.076	669.2

**Table 4. On-axis effective area of the CSX/SXT telescope design assuming 300 mm long mirrors.**Coating Gold (LBL optical constants), density 18.85 gm/cm<sup>3</sup>

Aperture obscuration=0.75

Energy (KeV) Effective area (cm<sup>2</sup>)

0.248	8621.1
0.252	8595.7
0.256	8574.0
0.260	8550.6
0.264	8528.2
0.268	8508.6
0.273	8494.7
0.277	8490.8
0.281	8481.8
0.286	8467.8
0.291	8452.8
0.295	8437.6
0.300	8422.9
0.305	8409.4
0.310	8399.1
0.315	8391.1
0.320	8381.3
0.325	8370.1
0.330	8359.0
0.336	8348.6
0.341	8339.7
0.347	8333.3
0.352	8334.2
0.358	8335.9
0.364	8333.1
0.370	8327.7
0.376	8321.2
0.382	8314.4
0.388	8307.8
0.394	8302.1
0.401	8299.6
0.407	8301.6
0.414	8300.5
0.420	8295.9
0.427	8290.0
0.434	8283.4
0.441	8276.4
0.448	8270.4
0.455	8266.3
0.463	8260.7
0.470	8253.2
0.478	8244.7
0.486	8235.5
0.493	8225.7
0.501	8215.5
0.510	8205.4
0.518	8195.4
0.526	8184.9
0.535	8174.0
0.543	8162.8

0.552	8151.7
0.561	8140.7
0.570	8130.8
0.579	8121.1
0.589	8111.0
0.598	8100.9
0.608	8090.9
0.618	8081.4
0.628	8072.7
0.638	8065.5
0.648	8061.5
0.659	8066.4
0.669	8071.1
0.680	8071.0
0.691	8069.3
0.702	8066.3
0.714	8062.4
0.725	8057.4
0.737	8051.3
0.749	8045.5
0.761	8039.8
0.773	8034.4
0.786	8029.5
0.799	8028.0
0.811	8030.7
0.825	8031.0
0.838	8030.9
0.852	8031.0
0.865	8031.5
0.879	8038.7
0.893	8054.0
0.908	8064.1
0.923	8072.7
0.938	8080.6
0.953	8089.0
0.968	8101.1
0.984	8113.3
1.000	8124.0
1.016	8134.4
1.032	8149.0
1.049	8175.0
1.066	8200.6
1.083	8222.1
1.101	8241.0
1.119	8257.9
1.137	8273.0
1.155	8286.6
1.174	8298.7
1.193	8309.3
1.212	8317.7
1.232	8320.8
1.251	8317.3
1.272	8315.1
1.292	8313.5
1.313	8313.7
1.334	8321.4

1.356	8328.4
1.378	8333.2
1.400	8336.8
1.423	8337.0
1.446	8328.3
1.469	8321.3
1.493	8320.5
1.517	8350.3
1.542	8371.9
1.567	8378.5
1.592	8365.7
1.618	8353.9
1.644	8344.5
1.671	8344.8
1.698	8330.7
1.725	8305.7
1.753	8288.7
1.781	8248.1
1.810	8201.2
1.839	8178.0
1.869	8134.3
1.899	8076.8
1.930	8039.2
1.961	7999.8
1.993	7931.5
2.025	7848.5
2.058	7757.8
2.091	7645.2
2.125	7494.6
2.159	7270.0
2.194	6904.7
2.230	5117.0
2.266	3291.1
2.303	3113.2
2.340	2712.7
2.378	3022.8
2.416	3264.9
2.455	3401.2
2.495	3491.9
2.535	3575.5
2.576	3643.2
2.618	3649.5
2.660	3628.7
2.703	3542.2
2.747	3289.0
2.791	3343.5
2.837	3472.5
2.882	3524.3
2.929	3579.4
2.976	3626.4
3.025	3650.4
3.074	3662.4
3.123	3647.7
3.174	3566.9
3.225	3548.5
3.277	3593.4

3.330	3609.7
3.384	3603.3
3.439	3555.7
3.494	3552.6
3.551	3600.6
3.608	3599.4
3.667	3591.9
3.726	3578.7
3.786	3560.8
3.848	3543.9
3.910	3520.9
3.973	3492.4
4.037	3460.8
4.103	3428.1
4.169	3392.4
4.236	3360.3
4.305	3284.4
4.375	3242.7
4.445	3189.6
4.517	3139.8
4.590	3086.3
4.665	3032.5
4.740	2976.8
4.817	2919.4
4.895	2859.8
4.974	2800.2
5.054	2736.8
5.136	2678.1
5.219	2620.9
5.303	2551.0
5.389	2508.3
5.476	2451.6
5.565	2396.1
5.655	2340.0
5.746	2283.3
5.839	2226.4
5.934	2179.3
6.030	2120.6
6.127	2070.2
6.226	2018.7
6.327	1967.2
6.429	1916.3
6.533	1865.8
6.639	1815.9
6.747	1766.5
6.856	1717.7
6.967	1669.4
7.079	1621.8
7.194	1574.9
7.310	1528.6
7.428	1482.9
7.548	1437.9
7.671	1393.7
7.795	1350.1
7.921	1307.2
8.049	1265.1

8.179	1223.6
8.311	1182.9
8.446	1142.9
8.582	1103.6
8.721	1065.0
8.862	1027.2
9.005	990.0
9.151	953.5
9.299	917.7
9.450	882.6
9.602	848.2
9.758	814.4
9.916	781.2
10.076	748.6

**Figure 1.** Effective areas of the CSX/SXT telescope designs. The solid line is for the design with 200 mm mirror length and dashed line is for the design with 300 mm mirror lengths. Gold coated surfaces are assumed. The area loss due to structures within the aperture is assumed to be 25%.

